APPENDIX A
WATER RESOURCES

A.1 SURFACE WATER NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM VOLUMES

One of the primary sources of potential impacts to surface water at the Los Alamos National Laboratory (LANL) is the National Pollutant Discharge Elimination System (NPDES) outfalls. NPDES outfall flow projections were prepared by alternative. Table A.1–1 identifies each industrial outfall by facility, outfall number, and watershed. The index discharge as of August 1996 is also presented along with outfall projections for each alternative.

A.2 GROUNDWATER HYDRAULIC PROPERTIES

The nature and extent of groundwater bodies in the LANL region has not been fully characterized. To better understand the hydrogeologic characterization of Pajarito Plateau, LANL personnel have prepared a Hydrogeologic Workplan (LANL 1998). The workplan proposes the installation of new wells that will further investigate the recharge and cross-connection mechanisms to the main aquifer (section 4.3.2.3). Current data indicate that groundwater bodies occur near the surface of the earth in canyon bottoms, alluvium, perched at deeper levels (intermediate perched groundwater), and at deeper levels in the main aquifer. Table A.2–1 presents summary information on the hydraulic parameters of groundwater bodies in the LANL region.

A.3 MAIN AQUIFER VOLUME ESTIMATES

The main aquifer is the only groundwater body within the LANL region that is sufficiently saturated and permeable to transmit economic quantities of water to wells for public use. Recharge of the main aquifer is not fully understood nor characterized. Recent investigations suggest that the majority of water pumped to date from the main aquifer has been from storage, with minimal recharge (Rogers et al. 1996). Because this groundwater body is the only source of potable water within the region, the amount of water available for future use is of interest to many.

For the purposes of the Site-Wide Environmental Impact Statement (SWEIS), water storage calculations were made using a model developed by the United States (U.S.) Geological Survey (USGS). For modeling regional flow in the main aquifer, USGS subdivided the main aquifer into eight layers, which have a total thickness of 5,600 feet (1,707 meters) (Figure A.3–1). The model grid uses 25 columns and 33 rows spaced at 1-mile intervals. The volume of water stored in any given cell is equal to the storage coefficient multiplied by the volume of the cell. For all cells, a value of 0.1554 was used for the storage coefficient, which was based on a specific yield value of 0.15 and specific storage capacity of 1×10^{-6} per foot. The volume of water stored beneath any given region is the sum of water stored in the cells, bounded by the region, and extending to the total depth of the aquifer.

The volume for the main aquifer beneath the Española Basin is underestimated by this model, as the basin actually extends beyond the modeled region (Figure A.3–2). Table A.3–1 presents a summary of the values used to calculate the amount of water stored in the main aquifer beneath the Pajarito Plateau (which is a subset of the total area that USGS modeled), the area from which the Department of Energy (DOE) water is drawn. Table A.3–2 presents a

TABLE A.1–1.—*Volume of NPDES by Watershed for Index and Alternatives*[a]

FACILITY[f]	OUTFALL	LEGEND[g]	TA[e]	BLDG.	DESCRIPTION[h]	WATERSHED	DISCHARGES[b] (MILLIONS OF GALLONS PER YEAR)				
							INDEX (08/96)	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
KEY FACILITIES											
HE Testing	04A–141	85	39	69	Light Gas Gun Fac.	Ancho	0.03				
HE Testing	04A–156	86	39	89	Gas Gun Shop	Ancho	0.09				
HRL	03A–040	08	43	01	HRL	Los Alamos	2.70	2.50	2.50	2.50	2.50
LANSCE	03A–047	18	53	60	Linac C-Tower	Los Alamos	2.64	4.70	7.10	2.30	7.10
LANSCE	03A–048	19	53	62	Linac C-Tower	Los Alamos	8.56	15.60	23.40	7.70	23.40
LANSCE	03A–049	20	53	64	Linac C-Tower	Los Alamos	4.15	7.50	11.30	3.70	11.30
Tritium	02A–129	11	21	155N,357	Steam Plant	Los Alamos	0.11	0.11	0.11	0.11	0.11
Tritium	03A–036	12	21	152, 155, 155N, 220	Lab., TSTA, C-Tower	Los Alamos	0.02				
Tritium	03A–158	14	21	209	TSFF	Los Alamos	0.22	0.22	0.22	0.11	0.11
Tritium	05S(STP)	15	21	227	Sewage treatment	Los Alamos	0.77				
CMR	03A–021	31	03	29	CMR	Mortandad	0.53	0.53	0.53	0.53	0.53
Plutonium	03A–181	38	55	06	Utility Bldg.	Mortandad	14.00	14.00	14.00	14.00	14.00
Radiochemistry	03A–045	37	48	01	RC-1	Mortandad	1.10	0.87	0.87	0.87	0.87
Radiochemistry	04A–016	34	48	01	RC-1	Mortandad	6.30				
Radiochemistry	04A–131	33	48	01	RC-1	Mortandad	0.95				
Radiochemistry	04A–152	36	48	28	RC-1	Mortandad	4.00				
Radiochemistry	04A–153	35	48	01	RC-1	Mortandad	3.20	3.20	3.20	3.20	3.20
RLWTF	EPA051	39	50	01	RLWTF	Mortandad	5.51	6.60	9.30	5.30	6.60
Sigma	03A–022	32	03	66,127,141	Sigma Complex	Mortandad	4.40	4.40	4.40	4.40	4.40
TFF	04A–127	40	35	213	TFF	Mortandad	2.00				
HE Processing	04A–115	49	08	70	NDT Facility	Pajarito	0.53				
HE Processing	05A–066	53	09	A,21,28	Lab, Shop	Pajarito	4.36	0.74	0.74	0.74	0.74
HE Processing	05A–067	51	09	B,41,42	Laboratory	Pajarito	0.33	0.33	0.33	0.33	0.33
HE Processing	05A–068	52	09	48	Machining Bldg.	Pajarito	1.16	0.06	0.06	0.06	0.06
HE Processing	06A–074	48	08	22	X-ray Bldg.	Pajarito	0.25				
HE Processing	06A–075	50	08	21	Laboratory	Pajarito	1.00				
HE Testing	04A–101	58	40	09	Firing Site	Pajarito	0.05				
HE Testing	04A–143	61	15	306	Hydrotest Bldg.	Pajarito	0.02	0.02	0.02	0.02	0.02

TABLE A.1–1.—*Volume of NPDES by Watershed for Index and Alternatives*[a]–Continued

FACILITY[f]	OUTFALL	LEGEND[g]	TA[e]	BLDG.	DESCRIPTION[h]	WATERSHED	DISCHARGES[b] (MILLIONS OF GALLONS PER YEAR)				
							INDEX (08/96)	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
HE Testing	06A–079	54	40	04	Firing Site	Pajarito	0.54	0.54	0.54	0.54	0.54
HE Testing	06A–080	55	40	05	Firing Site	Pajarito	0.03	0.03	0.03	0.03	0.03
HE Testing	06A–081	56	40	08	Firing Site	Pajarito	0.03	0.03	0.03	0.03	0.03
HE Testing	06A–082	59	40	12	Preparation Room	Pajarito	0.03				
HE Testing	06A–099	57	40	23	Laboratory	Pajarito	0.03				
HE Testing	06A–100	60	40	15	Firing Site	Pajarito	0.04	0.04	0.04	0.04	0.04
LANSCE	03A–113	21	53	293, 294, 1032	LEDA C-Towers	Sandia	0.90	39.70	39.80	12.30	39.80
LANSCE	03A–125	23	53	28	Proton Storage Ring	Sandia	0.18	0.18	0.18	0.18	0.18
LANSCE	03A–145	22	53	06	Orange Box Offices	Sandia	0.37				
Sigma	03A–024	30	03	35, 187	Press Bldg./ C. Tower	Sandia	2.90	2.90	2.90	2.90	2.90
HE Processing	02A–007	64	16	540	Steam Plant	Water	10.50	7.40	7.40	7.40	7.40
HE Processing	03A–130	81	11	30	Laboratory	Water	0.04	0.04	0.04	0.04	0.04
HE Processing	04A–070	65	16	220	X-ray Bldg.	Water	0.22				
HE Processing	04A–083	73	16	202	Shops	Water	0.20				
HE Processing	04A–092	80	16	370	Metal Forming	Water	1.57				
HE Processing	04A–157	75	16	460	Laboratory	Water	7.31				
HE Processing	05A–053	79	16	410	Assembly Bldg.	Water	0.12				
HE Processing	05A–054	68	16	340	HE Synthesis	Water	3.57	3.60	3.60	3.60	3.60
HE Processing	05A–055	78	16	401, 406	Pressure Tanks	Water	0.04	0.13	0.17	0.10	0.10
HE Processing	05A–056	67	16	260	Process Bldg.	Water	2.53				
HE Processing	05A–069	82	11	50	Drop Tower Sump	Water	0.00	0.00	0.00	0.00	0.00
HE Processing	05A–071	77	16	430	HE Pressing	Water	0.04	0.04	0.04	0.04	0.04
HE Processing	05A–072	74	16	460	Laboratory	Water	0.02				
HE Processing	05A–096	83	11	51	Drop Tower Sump	Water	0.00	0.00	0.00	0.00	0.00
HE Processing	05A–097	84	11	52	Drop Tower Sump	Water	0.00	0.00	0.00	0.00	0.00
HE Processing	06A–073	66	16	222	Dark Room	Water	0.08				
HE Testing	03A–028	72	15	184, 185, 202	Cooling Tower	Water	2.20	2.20	2.20	2.20	2.20
HE Testing	03A–185	70	15	184, 202	Cooling Tower	Water	0.73	0.73	0.73	0.73	0.73
HE Testing	04A–139	71	15	184	PHERMEX	Water	0.00				
HE Testing	06A–123	69	15	183	Laboratory	Water	0.13				

TABLE A.1–1.—Volume of NPDES by Watershed for Index and Alternatives[a]-Continued

FACILITY[f]	OUTFALL	LEGEND[g]	TA[e]	BLDG.	DESCRIPTION[h]	WATERSHED	DISCHARGES[b] (MILLIONS OF GALLONS PER YEAR)				
							INDEX (08/96)	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
Tritium	04A–091	76	16	450	Process Bldg.	Water	0.22				
	Sum, Key Facilities				59 Outfalls[d]		104	119	136	76	133
NON-KEY FACILITIES											
S&T	03A–042	44	46	01	Laboratory	Cañada del Buey	5.30	5.30	5.30	5.30	5.30
S&T	04A–118	46	54	1013	Pajarito #4 Well	Cañada del Buey	1.10	1.10	1.10	1.10	1.10
S&T	04A–166	43	05	26	Pajarito #5 Well	Cañada del Buey	0.01	0.01	0.01	0.01	0.01
S&T	03A–038	87	33	114	Support Bldg.	Chaquehui	5.80				
S&T	04A–171	07	NF	01	Guaje #1 Well	Guaje	0.00	0.00	0.00	0.00	0.00
S&T	04A–172	06	NF	01A	Guaje #1A Well	Guaje	0.00	0.00	0.00	0.00	0.00
S&T	04A–173	05	NF	02	Guaje #2 Well	Guaje	0.00	0.00	0.00	0.00	0.00
S&T	04A–174	04	NF	04	Guaje #4 Well	Guaje	0.00	0.00	0.00	0.00	0.00
S&T	04A–175	02	NF	05	Guaje #5 Well	Guaje	0.00	0.00	0.00	0.00	0.00
S&T	04A–176	01	NF	06	Guaje #6 Well	Guaje	0.66	0.66	0.66	0.66	0.66
S&T	04A–177	03	NF	B1	Guaje Booster #1 Well	Guaje	0.06	0.06	0.06	0.06	0.06
S&T	03A–034	13	21	166	Equipment Bldg.	Los Alamos	0.26				
S&T	03A–035	10	21	210	Research Bldg.	Los Alamos	0.04				
S&T	04A–182	09	21	1003	Backflow Preventer	Los Alamos	0.00	0.00	0.00	0.00	0.00
S&T	04A–186	16	21	452	Otowi #4 Well	Los Alamos	0.18	0.18	0.18	0.18	0.18
S&T	03A–160	41	35	124	Antares Target Hall	Mortandad	5.10	5.10	5.10	5.10	5.10
S&T	06A–132	42	35	87	Laboratory	Mortandad	5.80				
S&T	03A–025	47	03	208	Equipment Bldg.	Pajarito	0.18	0.18	0.18	0.18	0.18
S&T	04A–164	63	18	252	Pajarito #2 Well	Pajarito	0.01	0.01	0.01	0.01	0.01
S&T	06A–106	62	36	01	Laboratory	Pajarito	0.58	0.58	0.58	0.58	0.58
S&T	04A–161	17	72	01	Otowi #1 Well	Pueblo	1.00	1.00	1.00	1.00	1.00
S&T	01A–001[c]	27	03	22	Power Plant	Sandia	77.9	113.90	113.90	113.90	113.90
S&T	03A–027	28	03	285	Cooling Tower	Sandia	5.80	5.80	5.80	5.80	5.80
S&T	03A–148	26	03	1498	Data Center	Sandia	6.30				
S&T	04A–094	29	03	170	Gas Facility	Sandia	5.30				
S&T	04A–163	25	72	04	Pajarito #1 Well	Sandia	6.20	6.20	6.20	6.20	6.20
S&T	04A–165	24	72	07	Pajarito #3 Well	Sandia	2.00	2.00	2.00	2.00	2.00

TABLE A.1–1.—*Volume of NPDES by Watershed for Index and Alternatives*[a]-Continued

FACILITY[f]	OUTFALL	LEGEND[g]	TA[e]	BLDG.	DESCRIPTION[h]	WATERSHED	DISCHARGES[b] (MILLIONS OF GALLONS PER YEAR)				
							INDEX (08/96)	NO ACTION	EXPANDED OPERATIONS	REDUCED OPERATIONS	GREENER
	Sum, Non-Key Facilities				28 Outfalls[c,d]		130	261	142	142	142
	LANL Total						233	261	278	218	275

[a] NPDES Information Sources: Index information was provided by the Surface Water Data Team Reports of August 1996 (Bradford 1996) and as modified in 1997 (Garvey 1997). Outfall flow projections for the alternatives were based on the outfalls remaining as of November 1997.

[b] When no discharge is indicated under the alternative, this means the outfall was eliminated. For outfalls with 0.00 flow, this means the outfall still remains but the projected flow is so small that it was rounded down to zero.

[c] All effluent from the TA–46 Sewage Treatment Facility Sanitary Waste System Consolidation (SWSC) is pumped to a re-use tank adjacent to the TA–3 power plant. When the power plant is in operation, water is drawn from the tank as make-up for the power plant cooling towers where it is either lost to the air through evaporation or discharged to Sandia Canyon via the power plant Outfall 01A–001. For the index flow, of the total 77.9 MGY flow for Outfall 01A–001, approximately 29.0 MGY is contributed by SWSC as make-up water. For the other four alternatives, of the total 113.9 million gallons per year (MGY) flow for Outfall 01A–001, approximately 65 MGY is contributed by SWSC as make-up water. Outfall 13S is located at the TA–46 SWSC facility but is not used. Outfall 13S, although not listed in the table, is added to the number of outfalls, making a total of 28 outfalls for the non-key facilities.

[d] Number of outfalls identified, 59 and 28, for key and non-key, respectively, are for the index outfalls. The number of outfalls for all the alternatives is 33 and 28 for key and non-key, respectively. This reduction in outfalls from the index for key facilities is due to LANL's ongoing Outfall Reduction Program. Outfall flow projections for the alternatives were based on the outfalls remaining as of November 1997.

[e] NF = National Forest

[f] HE = High explosives, HRC = Health Research Facility, LANSCE = Los Alamos Neutron Science Center, CMR = Chemistry and Metallurgy Research, RLWTF = Radioactive Liquid Waste Treatment Facility, TFF = Target Fabrication Facility, S&T = Science and Technology

[g] Legend numbers correspond to NPDES locations shown in Figure 4.3.1.3–1

[h] TSTA = Tritium System Test Assembly, TSFF = Tritium Science and Fabrication Facility, NDT = Nondestructive Testing, LEDA = Low-Energy Demonstration Accelerator, PHERMEX = Pulsed High-Energy Radiation Emitting X-Ray Facility

TABLE A.2–1.—*Hydraulic Characteristics of Groundwater Bodies, LANL Region*

	POROSITY (%)	HYDRAULIC CONDUCTIVITY (cm/sec)
Alluvium[a] (may contain alluvial groundwater)	43	4.00E-04
Tuff[a] (may contain intermediate perched groundwater)	48	2.00E-04
Main Aquifer Formations[b,c]		
Puye Formation		4.60E-04
Tesuque Formation		3.00E-04
Tschicoma Formation		9.00E-04

[a] Data from Rogers and Gallaher 1995.
[b] Data from Purtymun 1984. Hydraulic conductivity converted from gallons per day per square foot, cm/sec is centimeters per second.
[c] Porosity values for the main aquifer formations are not readily available from the published literature.
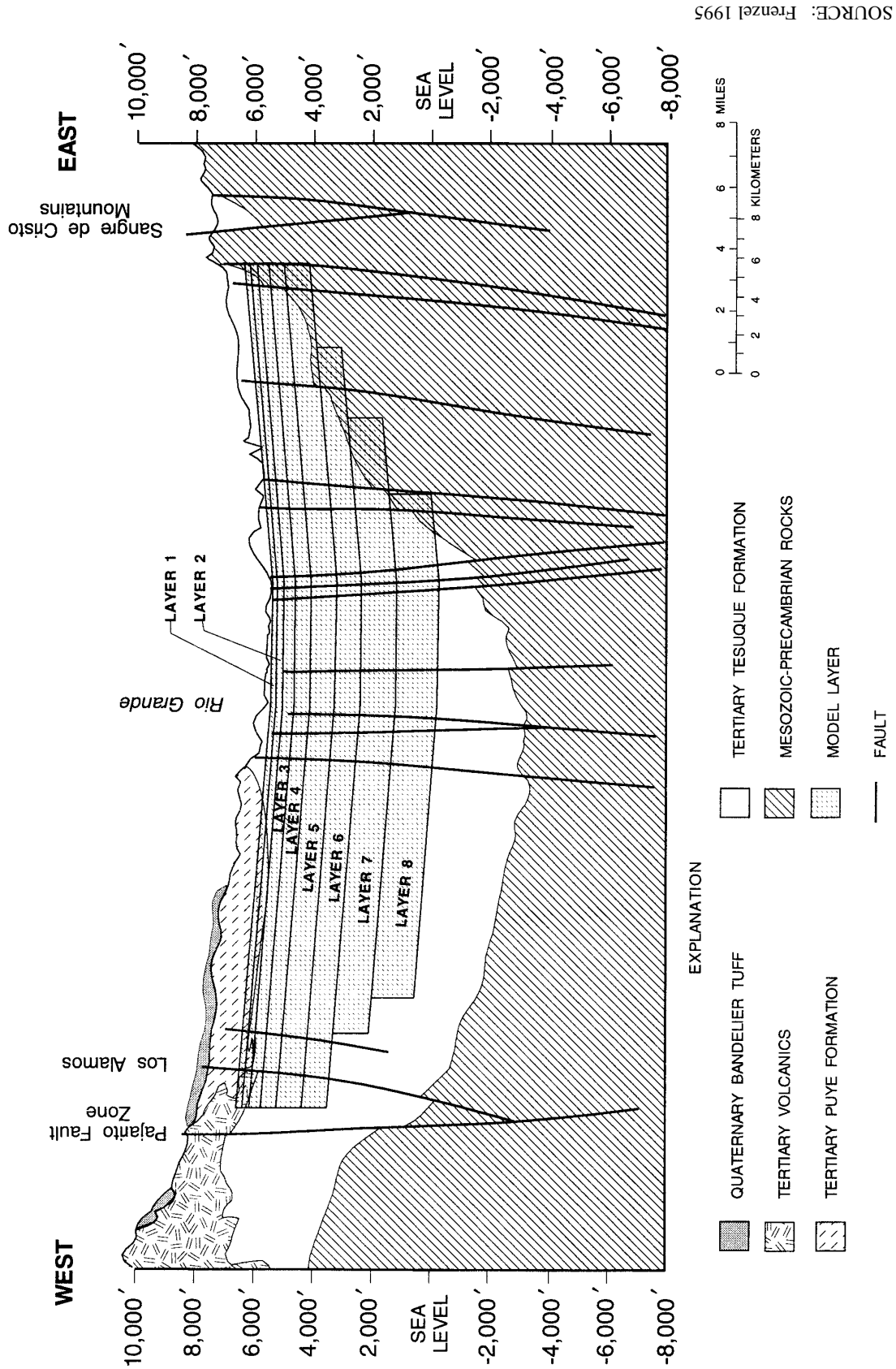
FIGURE A.3–1.—*Diagrammatic Section of Model Layers and Subsurface Geology.*

EXPLANATION

QUATERNARY BANDELIER TUFF

TERTIARY VOLCANICS

TERTIARY PUYE FORMATION

TERTIARY TESUQUE FORMATION

MESOZOIC-PRECAMBRIAN ROCKS

MODEL LAYER

FAULT

WEST

EAST

Sangre de Cristo Mountains

Rio Grande

Los Alamos

Pajarito Fault Zone

LAYER 1
LAYER 2
LAYER 3
LAYER 4
LAYER 5
LAYER 6
LAYER 7
LAYER 8
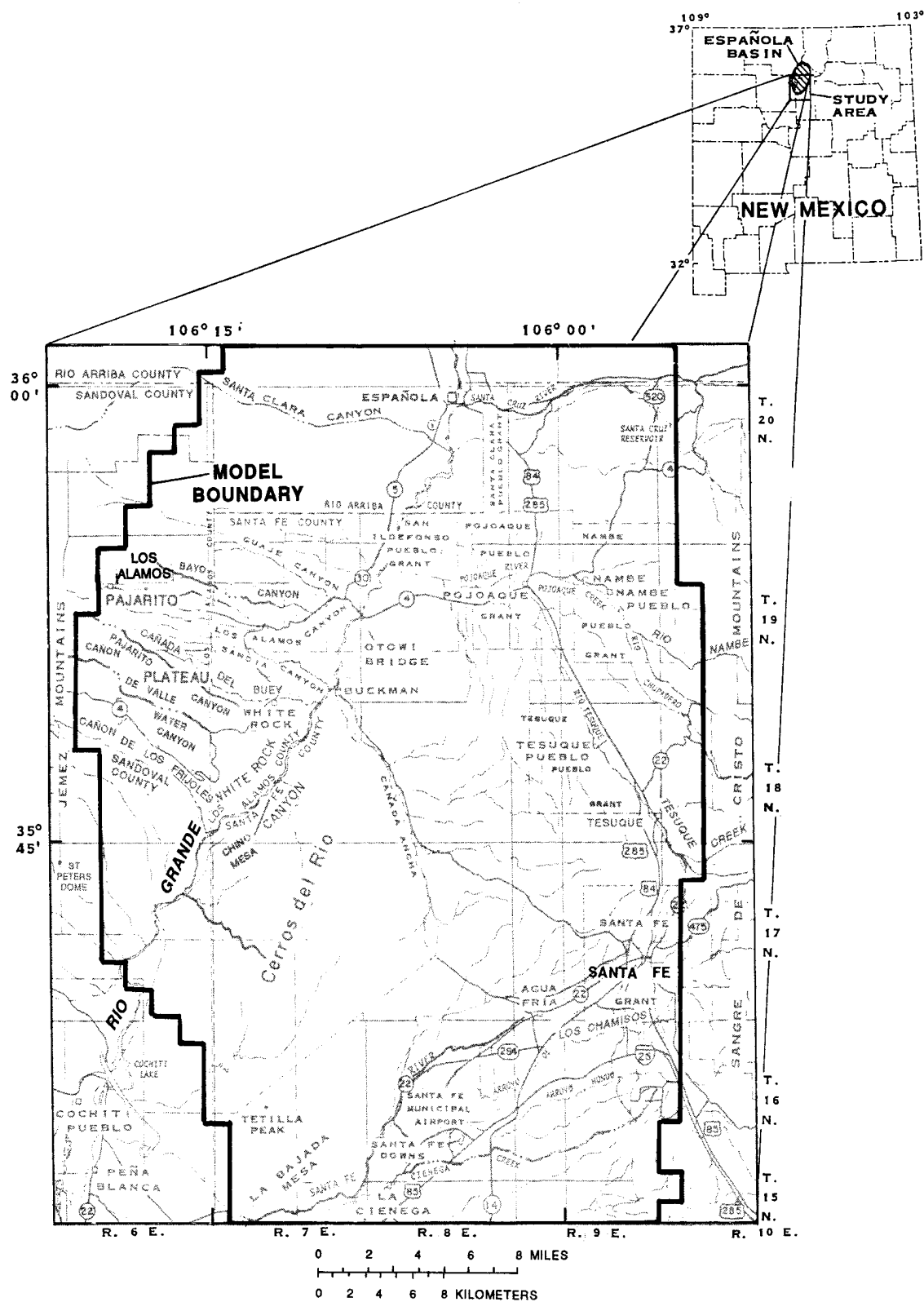
FIGURE A.3–2.—*Area USGS Modeled.*

SOURCE: Frenzel 1995

TABLE A.3–1.—*Estimated Water Storage of Main Aquifer Beneath Pajarito Plateau*

MODEL LAYER NO.	(A) LAYER THICKNESS (FEET)	(B) NUMBER OF ACTIVE CELLS IN REGION	(C) VOLUME OF AQUIFER IN THE LAYER (CUBIC FEET)	(D) STORAGE COEFFICIENT (CUBIC FEET OF WATER PER CUBIC FEET OF AQUIFER)	(E) VOLUME OF WATER WITHIN LAYER (CUBIC FEET)	(F) CUMULATIVE AQUIFER THICKNESS (FEET)	(G) CUMULATIVE WATER VOLUME (CUBIC FEET)	(H) CUMULATIVE WATER VOLUME (GALLONS)	(I) CUMULATIVE YEARS TO DEPLETE AT DOE WATER RIGHTS RATE (SEE TABLE A.3–3)
1	200	124	6.91384E+11	0.1554	1.07441E+11	200	1.07441E+11	$8.0376710 \times 10^{+11}$	445
2	275	124	9.50653E+11	0.1554	1.47732E+11	475	2.55173E+11	$1.9089510 \times 10^{+12}$	1,058
3	325	124	1.1235E+12	0.1554	1.74592E+11	800	4.29764E+11	$3.2150710 \times 10^{+12}$	1,781
4	475	124	1.64204E+12	0.1554	2.55173E+11	1,275	6.84937E+11	$5.1240110 \times 10^{+12}$	2,839
5	725	124	2.50627E+12	0.1554	3.89474E+11	2,000	1.07441E+12	$8.0376710 \times 10^{+12}$	4,453
6	1,000	124	3.45692E+12	0.1554	5.37206E+11	3,000	1.61162E+12	$1.2056510 \times 10^{+13}$	6,680
7	1,200	119	3.98104E+12	0.1554	6.18683E+11	4,200	2.23037E+12	$1.6684610 \times 10^{+13}$	9,244
8	1,400	119	4.44939E+12	0.1554	6.91436E+11	5,600	2.92171E+12	$2.1857310 \times 10^{+13}$	12,109

Formulas:

C = A x [(5,280 feet/mile)^2] x B

E = C x D

F = sum of current layer thickness plus thickness of all layers above

G = sum of current layer water volume plus water volumes of all layers above

H = G x 7.481 gallons per cubic foot

I = H/(1,805 million gallons per year); calculations are conservatively based on 100% usage of total DOE water rights.

Source: Frenzel 1995

TABLE A.3–2.—Estimated Water Storage of Main Aquifer Within the Area USGS Modeled

MODEL LAYER NO.	(A) LAYER THICKNESS (FEET)	(B) NUMBER OF ACTIVE CELLS IN REGION	(C) VOLUME OF AQUIFER IN THE LAYER (CUBIC FEET)	(D) STORAGE COEFFICIENT (CUBIC FEET OF WATER PER CUBIC FEET OF AQUIFER)	(E) VOLUME OF WATER WITHIN LAYER (CUBIC FEET)	(F) CUMULATIVE AQUIFER THICKNESS (FEET)	(G) CUMULATIVE WATER VOLUME (CUBIC FEET)	(H) CUMULATIVE WATER VOLUME (GALLONS)	(I) CUMULATIVE YEARS TO DEPLETE AT TOTAL WATER RIGHTS RATE (SEE TABLE A.3–3)
1	200	712	3.97×10^{12}	0.1554	6.169×10^{11}	200	6.169×10^{11}	4.61518×10^{12}	475
2	275	712	5.459×10^{12}	0.1554	8.483×10^{11}	475	1.465×10^{12}	1.0961×10^{13}	1,127
3	325	712	6.451×10^{12}	0.1554	1.002×10^{12}	800	2.468×10^{12}	1.84607×10^{13}	1,899
4	475	684	9.058×10^{12}	0.1554	1.408×10^{12}	1,275	3.875×10^{12}	2.89907×10^{13}	2,982
5	725	685	1.385×10^{13}	0.1554	2.152×10^{12}	2,000	6.027×10^{12}	4.50863×10^{13}	4,637
6	1,000	607	1.692×10^{13}	0.1554	2.63×10^{12}	3,000	8.656×10^{12}	6.47592×10^{13}	6,660
7	1,200	533	1.783×10^{13}	0.1554	2.771×10^{12}	4,200	1.143×10^{13}	8.54886×10^{13}	8,792
8	1,400	442	1.725×10^{13}	0.1554	2.681×10^{12}	5,600	1.411×10^{13}	1.05544×10^{14}	10,855

Formulas:

C = A x [(5,280 feet/mile)^2] x B

E = C x D

F = Sum of current layer thickness plus thicknesses of all layers above

G = Sum of current layer water volume plus water volumes of all layers above

H = G x 7.481 gallons per cubic foot

I = H/(9,723 million gallons per year); calculations are conservatively based on 100% usage of total water rights for the Española Basin.

Source: Frenzel 1995

summary of the values used to calculate the water stored in the main aquifer within the area studied by the USGS (Figure A.3–2). These two tables also reflect the number of years it would take to deplete the water stored beneath these areas for each level modeled based on 100 percent use of water rights by the major users who draw from these areas. The total water rights used for these calculations are reflected in Table A.3–3.

It should be noted that these calculations do not consider recharge to or discharge from the aquifer or pumping from wells outside the control volume (e.g., Española, Santa Fe, San Ildefonso wells). Also, the water level changes projected by the regional MODFLOW model represent average changes over a whole grid-cell (i.e., a square that is a mile on a side). They are for the most part not predictive of the water level changes at any single point within the cell (for example, a supply well). Pumping wells have characteristic "cones of depression" where the water surface reflects an inverted cone, and water levels at the well may be quite different from levels even a few ten's of feet away. Whether any individual well would exhibit water level changes consistent with the predicted grid-cell average change is a function of, for example, its location within the grid-cell; proximity to other pumped wells; and the individual well operation, construction, and hydraulics. Hence, the water level changes predicted by the model can only be considered

TABLE A.3–3.—*Water Rights for Española Basin*

USER	WATER RIGHTS (GAL/YR)	TOTAL
DOE	1.805E+09	18.6%
Santa Fe	7.012E+09	72.1%
Espanola	9.060E+08	9.3%
TOTAL (J)	9.723E+09	100.0%

Source: PC 1996

qualitatively and not be considered as finite changes.

A.4 DEVELOPMENT OF GROUNDWATER MODEL INPUT FILES

A.4.1 Water Use Projections

Table A.4.1–1 presents annual water use projections. The following processes were used to generate the numbers shown in Table A.4.1–1:

- *LANL Water Use.* The SWEIS alternatives were reviewed to determine changes in water use across LANL. Because technical area (TA)–53 is a major user of water at LANL and is individually metered for water use, projections for this facility were made separate from the rest of LANL. While projections for maximum annual use were developed for the SWEIS under each alternative (for comparison to the DOE Water Rights in the Socioeconomic Analyses in chapter 5), use rates for each of the next 10 years were developed separately for the purposes of assessing drawdown of the main aquifer. These annual projections, were developed using the average annual LANL use from 1990 through 1994 (LANL 1992, LANL 1993, LANL 1994, LANL 1995, and LANL 1996). This baseline value was used for the 10-year projections, to which facilities use data (based on projected construction and operations in each alternative) were added or subtracted as appropriate. These projections include reductions of 26 million gallons (99 million liters) per year, due to the TA–16 steam plant upgrade, and 10 million gallons (38 million liters) per year, due to the High Explosives Wastewater Treatment Facility upgrade.
- *Los Alamos County Water Use.* Data from 1990 through 1994 indicate an average per

TABLE A.4.1–1.—*Annual Water Use Projections*

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
TOTAL USE FOR LANL AND COUNTY (IN MILLION GALLONS)											
No Action	1,600	1,600	1,600	1,534	1,534	1,620	1,620	1,620	1,620	1,620	1,620
Expanded Operations	1,691	1,691	1,665	1,665	1,751	1,751	1,751	1,751	1,751	1,751	1,751
Reduced Operations	1,470	1,470	1,444	1,444	1,457	1,457	1,444	1,444	1,444	1,444	1,444
Greener	1,637	1,637	1,611	1,611	1,697	1,697	1,697	1,697	1,697	1,697	1,697
PERCENTAGE OF DOE WATER RIGHT (1,805 MILLION GALLONS)											
No Action	86%	86%	85%	85%	90%	90%	90%	90%	90%	90%	90%
Expanded Operations	94%	94%	92%	92%	97%	97%	97%	97%	97%	97%	97%
Reduced Operations	81%	81%	80%	80%	81%	81%	80%	80%	80%	80%	80%
Greener	91%	91%	89%	89%	94%	94%	94%	94%	94%	94%	94%

capita use of 155.8 gallons (589.7 liters) per day. This per capita use was applied to conservative projections (these are considered conservative because limited land availability would likely prevent the population from growing anywhere near the maximum projection) for the county population as follows: No Action, 18,969; Expanded Operations, 19,924; Reduced Operations, 17,394; and Greener, 18,969. These numbers were assumed constant through the entire 10-year period, effective January 1, 1996. These numbers were multiplied by the average per capita use figure to obtain the total Los Alamos County use figures shown. Bandelier water use is included in these calculations, because the per capita use factor included data from Bandelier.

The total use from DOE Water Rights was calculated by adding the results of the LANL use calculations and the Los Alamos County calculations.

- *Santa Fe County Water Use*. The Santa Fe County population figures used to calculate water use (Table A.4.1–2) were based on projected populations at 5-year intervals, prepared by the University of New Mexico's (UNM's) Bureau of Business and Economic Research (UNM 1994). A second-order polynomial was fit to the data to calculate the annual numbers shown in the second column. The number of new consumers for the public system was calculated based on estimates from Sangre de Cristo Water Company, because new developments are expected to use less water (142 gallons [540 liters] per day per person) than existing users (172 gallons [654 liters] per day per person). The per capita figure averages include irrigation and industrial use. To calculate the total public system water use, the percentage of Santa Fe County served by the Sangre de Cristo Water Company (57 percent) was assumed constant. For years 1996 through 2006, the projected water increases based on per

TABLE A.4.1–2.—*Estimated Annual Water Use for Santa Fe County*

YEAR	SANTA FE COUNTY POPULATION PROJECTION	NEW CONSUMERS	TOTAL WATER USE (gal./yr)	TOTAL WATER USE (acft/yr)
1993	105,089		3,741,505,919	11,481.5
1994	107,194		3,816,442,704	11,711.5
1995	109,326		3,892,360,000	11,944.4
1996	111,486	2,160	3,955,845,398	12,139.2
1997	113,674	4,347	4,020,140,288	12,336.5
1998	115,889	6,562	4,085,244,669	12,536.3
1999	118,131	8,805	4,151,158,542	12,738.6
2000	120,401	11,075	4,217,881,905	12,943.4
2001	122,699	13,372	4,285,414,760	13,150.6
2002	125,024	15,697	4,353,757,106	13,360.3
2003	127,376	18,050	4,422,908,944	13,572.5
2004	129,376	20,430	4,492,870,273	13,787.2
2005	132,164	22,838	4,563,641,093	14,004.4
2006	134,599	25,273	4,635,221,404	14,224.0

gal./yr = gallons per year
acft/yr = acre-feet per year

capita increases were added to the actual water use value for 1995.

A.4.2 Other Input Files and Information

Frenzel's model (1995) for north-central New Mexico, was used with no changes to any hydraulic parameters and no additional calibration. Data on water use from individual DOE and Santa Fe wells from 1993 through 1995 were obtained from the state engineers office and added to Frenzel's well input file, which used pumping data through 1992 (Frenzel 1995). Changes were made only to well pumping rates calculated from the water use projections. The process below describes the procedure for reducing annual total well field production to pumping from each model layer for each individual well. This process was performed for each alternative.

- To allocate the total use for the DOE and Santa Fe supply systems among individual wells, a spreadsheet was developed to calculate average percentage of the total produced by each well field from 1993 through 1995. In turn, the average proportion of the total well field production supplied by each individual well within the field was calculated from 1993 through 1995.
- For projected pumping rates for each well based on water use projections, a spreadsheet was developed based on Frenzel's (1995) Table 11. Frenzel's Table 11 allocates the percentage of pumping from layers one through five for each well. These percentages were multiplied by each well's total annual projected pumping to obtain the proper flow rate from each layer.
- Based on conversations with representatives of the Sangre de Cristo Water Company (Santa Fe County's public supplier) in 1995, Santa Fe plans to start taking their San Juan-Chama water right (5,605 acre-feet [or 1,827 million gallons

(6,913 million liters)] per year) from the Rio Grande through a diversion pipeline (Santa Fe Diversion). When the collection system for the Rio Grande is on-line, Santa Fe will shut down the Buckman well field and use it only for supply emergencies.

A.5 MODEL RESULTS

Based on the Frenzel model, the total approximate volume of water within the 5,600-foot (1,707-meter) thickness of the main aquifer below the Pajarito Plateau is estimated to be 21.8 trillion gallons (82,513 million cubic meters). Water quality will generally become increasingly poor with increasing depth. Therefore, the amount of potable water may be far less than the total volume available. Available data are insufficient to model water quality degradation with depth; but, water supply wells screened as deep as 1,830 feet (558 meters) into the main aquifer produce potable water that meets *Safe Drinking Water Act* standards (42 United States Code [U.S.C.] §300).

A similar water storage analysis for the main aquifer beneath the entire USGS modeled area shows that 106 trillion gallons (401 trillion liters) of water are stored. This estimate of storage volume is conservative, as the USGS model does not include the entire Española Basin. Use of groundwater from the Española Basin at combined annual water rights rates for DOE (1,805 million gallons [6,832 million liters] per year); Santa Fe (7,012 million gallons [26,540 million liters] per year); and Española (906 million gallons [3,429 million liters] per year) indicates that if the upper 1,275 feet (389 meters) of the Basin were used, a water supply would be available for 2,982 years and if the upper 2,000 feet (610 meters) of the Basin were used, a water supply would be available for 4,637 years.

A.5.1 Changes in Water Levels and Storage in the Main Aquifer

The model results reflect water level changes at the top of the main aquifer across the alternatives, given continued draw from the aquifer by DOE, Española, and Santa Fe. Table A.5.1–1 shows predicted water level changes at the surface of the main aquifer during the period from 1996 through 2006 for each of the SWEIS alternatives. Although the water use modeled includes water use in Española and Santa Fe, the differences between the alternatives are due only to LANL operations.

The groundwater model indicates that no springs in White Rock Canyon are likely to go dry. Springs in White Rock Canyon in the vicinity of the Buckman well field may actually increase in flow due to rising groundwater levels (from 0.1 to 3.8 feet [0.03 to 1.2 meters]). The rising water levels result from the continuing recovery in the vicinity of the Los Alamos well field, which was shut down in 1992, and recovery in the vicinity of Santa Fe's Buckman well field, which is planned for shut down in 1999. Operations of both well fields are independent of the alternatives and significantly affect water levels in the main aquifer in the vicinity of the Rio Grande.

TABLE A.5.1–1.—*Maximum Water Level Changes at the Top of the Main Aquifer Due to All Users Combined (1996 Through 2006)*

	WATER LEVEL CHANGE IN FEET[a]			
	NO ACTION	EXPANDED	REDUCED	GREENER
AREA OF CONCERN ON-SITE				
Pajarito Well Field	-13.2	-15.6	-10.7	-14.5
Otowi Well Field (Well 0–4)	-12.9	-15.2	-10.3	-14.2
AREA OF CONCERN OFF-SITE				
DOE - Guaje Well Field	-8.7	-9.3	-8.1	-9.0
Santa Fe Water Supply				
Buckman Well Field	+21.6	+21.6	+21.7	+21.6
Santa Fe Well field	-20.6	-20.6	-20.6	-20.6
San Juan Chama Diversion	0.0	0.0	0.0	0.0
Springs				
White Rock Canyon Springs, maximum drop	0.0	0.0	0.0	0.0
White Rock Canyon Springs, maximum rise	+1.0	+1.0	+1.0	+1.0
Other Springs (Sacred, Indian)	+3.8	+3.8	+3.8	+3.8
San Ildefonso Pueblo Supply Wells				
West of Rio Grande:				
Household, Community Wells	+0.6	+0.6	+0.6	+0.6
Los Alamos Well Field	+3.8	+3.8	+3.8	+3.8
East of Rio Grande:				
Household, Community Wells	0.0	0.0	0.0	0.0

[a] Negative value (-) indicates water level drop; positive value (+) indicates water level rise.

In comparison to the thicknesses of the eight model layers (total equals 5,600 feet [1,707 meters]), the maximum drawdown predicted over the next 10 years for DOE well fields (15.6 feet [4.8 meters] for the Pajarito well field) represents a reduction of main aquifer saturated thickness of 0.28 percent. Water use projections indicate that the maximum total volume of water to be withdrawn from DOE well fields from 1996 through 2006 is 19 billion gallons (72 billion liters), which is 0.09 percent of the main aquifer volume (22 trillion gallons [83 trillion liters]) of water in storage beneath the Pajarito Plateau. In summary, the drawdowns in DOE well fields are minimal relative to the total thickness of the main aquifer, and the volume of water to be used over the period from 1996 through 2006 is negligible relative to the volume of water in storage.

The water level declines reflected here could have an impact on the water levels in off-site wells that are used by other entities, which would require these entities to drill deeper wells into the aquifer.

A.6 MODEL UNCERTAINTIES AND LIMITATIONS

The following uncertainties and limitations associated with the use of this model should be noted:

- The model only includes a portion of the main aquifer. No model or method exists to predict changes of water levels in the vicinity of springs emanating from intermediate perched groundwater bodies (Basalt Spring, S-Site (TA–16) Springs, Water Canyon Gallery).

- The model's mile-square grid spacing underestimates drawdowns at individual wells. The grid spacing is also too large to precisely model changes in water levels in the main aquifer adjacent to the Rio Grande in response to the Santa Fe diversion. A finer-scale model is under development by the Sangre de Cristo Water Company.

- No additional calibration was performed, even though Otowi-4 pumping, initiated after Frenzel's model was calibrated, may make additional calibration technically desirable.

- Because water levels at the Pueblo of San Ildefonso are not available, modeled water level changes are the only data available.

- The remainder of Santa Fe County is served by approximately 16,000 domestic wells, each of which has rights to 3 acre-feet (0.98 million gallons [3.7 million liters]) per year. These are far more private wells than were included in the model (200). This factor probably does not significantly change model drawdown results for the following reasons: most private users probably use much less than 3 acre-feet (0.98 million gallons [3.7 million liters]) per year, the private wells extract only from layer one or shallower perched zones (public supply wells pump from layers two through five), and private wells are sufficiently spread out so that impacts from one location are not observed at other nearby wells.

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